ION Engineering
Bold science for clean energy

Novel Solvent System for CO_2 Capture

2010 NETL CO_2 Capture Technology Meeting

Pittsburgh, PA

September 2010

ION Engineering – Company Background

- A Boulder, Colorado company
- Founded in late 2008 by co-inventors and business team
  - Core technology invented at CU (Chemical Engineering)
  - Significant start-up, industry and financial expertise
- Commercializing novel solvents for industrial gas separation processes

Multiple Markets for ION Technology

Gas Clean-up
(High Pressure)

Current commercial market
No “Carbon Price” required
Process savings significant

Carbon Capture
(Low Pressure)

R&D market
Aggressive DOE goals
Increasing industry interest

ION – Project Overview

- 17 month project (Oct. 2010 – Feb. 2012)
- Key activities
  - Laboratory analysis and testing
  - Simulation model validation
  - Field testing with actual flue gas
  - Economic/operational analysis for commercial scale development
- $4.3 million project of which 71% funded by DOE

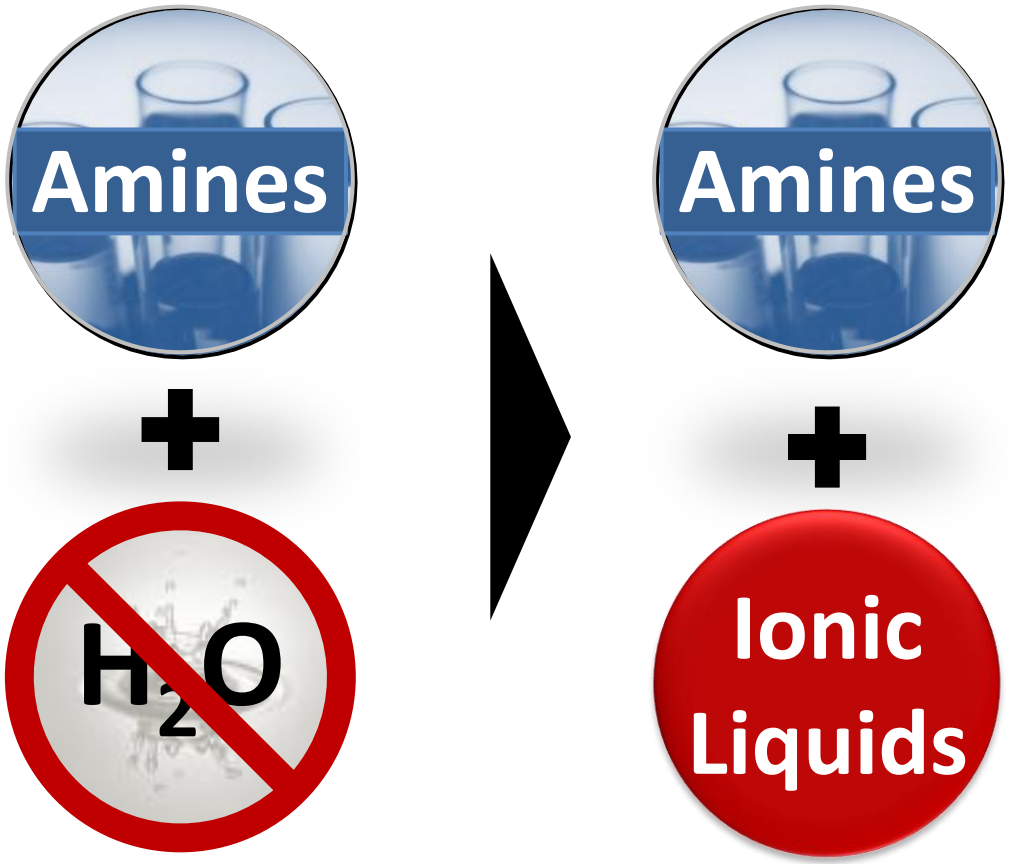
Field test site – Xcel Energy's Valmont Station Boulder, Colorado

Project participants

Xcel Energy® RESPONSIBLE BY NATURE™ | EPRI ELECTRIC POWER RESEARCH INSTITUTE | EVONIK INDUSTRIES | THE UNIVERSITY OF ALABAMA

Eltron Research & Development | CONTINENTAL TECHNOLOGIES | WorleyParsons resources & energy

…a new (elegantly simple) solvent approach



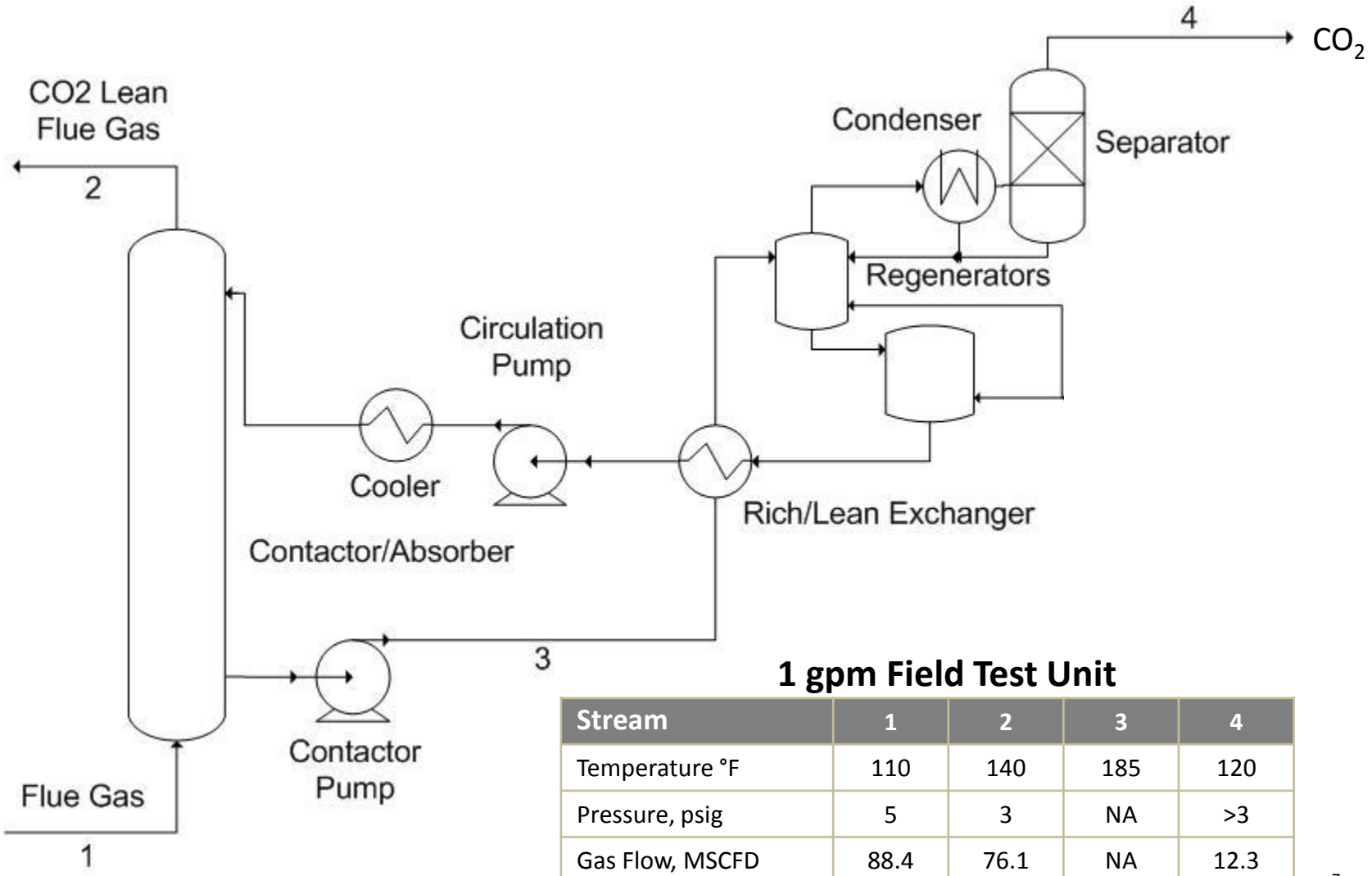
Which Ionic Liquid?

Typical properties are important:

- Non-volatile – do not evaporate
- Chemically stable
- Thermally stable
- Non-flammable
- Viscosity

But ION's focus is economics and functionality

ION – Technology Fundamentals



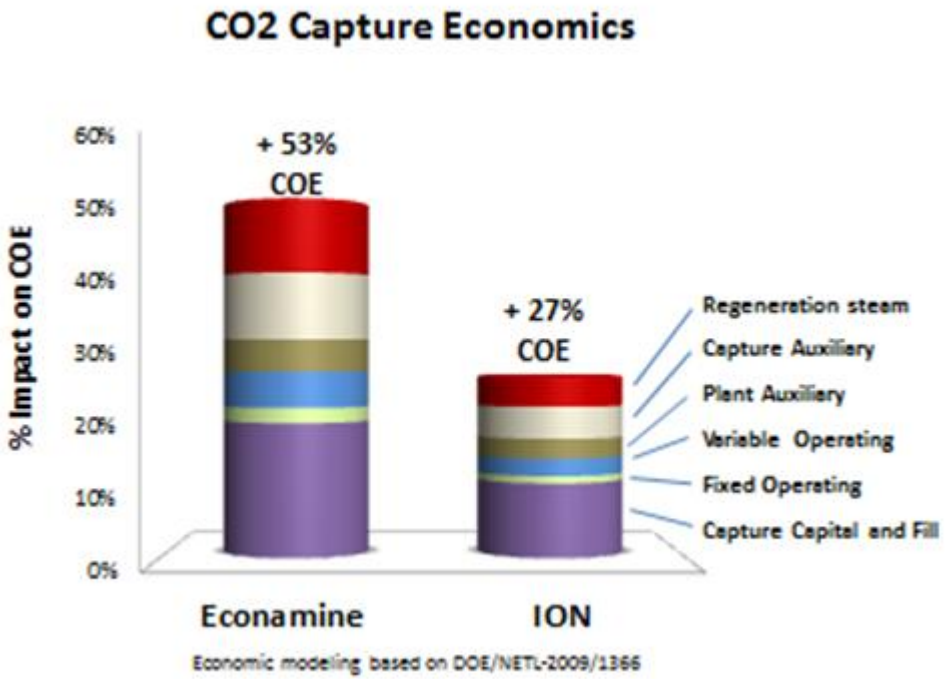
1 gpm Field Test Unit

Stream	1	2	3	4
Temperature °F	110	140	185	120
Pressure, psig	5	3	NA	>3
Gas Flow, MSCFD	88.4	76.1	NA	12.3

ION – Technology Fundamentals

Technical and Economic Benefits

- Lower energy requirements
- Higher solvent loading
- Leaner solvent return
- Smaller unit footprint
- Lower cost materials



ION – Technical and Economic Challenges

Compared to conventional processes…

- **Absorption Section**
  - Handling relatively higher viscosity materials
  - Managing heat balance
- **Regeneration Section**
  - Optimizing higher heat conditions for a leaner solvent return
  - Minimizing amine degradation and solvent loss
- **Process Chemistry with Power Plant Flue Gas**
  - Assessing effects of various contaminants
  - Validating simulation modeling with operating data

ION – Project Objectives & Methodology

Phase 1: Detailed Design (Oct 2010 – Mar 2011)

Objective: Develop a detailed process design for a 1-3 gpm (25-75 kW_{th}) field test unit using a validated process simulation model.

Methodology:

1. Evaluate solvent properties for flue gas conditions (VLE for CO_2, N_2, O_2 and H_2O; physical properties; and contaminants)
2. Use findings to create dataset(s) for a simulation model (ProMax)
3. Design, build and operate continuous system in lab (~ 3 KW_{th})
4. Validate model to experimental data from lab unit
5. Finalize detailed engineering design of field unit

ION – Project Objectives & Methodology

Phase 2: Process Operation & Evaluation (Apr 2011 – Jan 2012)

Objectives: Provide a technical and economic assessment for a commercial scale unit based on field tests using actual flue gas.

Methodology:

1. Test on-site at operating coal-fired power plant
   - Mobile "plug in" 1-3 gpm (~ 25-75 KW_{th}) integrated system
   - Flue gas tie-ins (downstream of other control technology)
2. Analyze data and reconcile with simulation model
3. Simulate commercial scale process
4. Determine technical and economic expectations at commercial scale

Future testing and development

- Mobile field unit offers potential for additional small-scale tests
  - Assess effects of longer duration tests
  - Determine effects of contaminant spikes
  - Monitor variations in flue gas
  - Assess design modifications for gas-fired generation

- Continue design optimization, demonstration and evaluation
  - Validate scale-up designs
  - Optimize plant integration issues – energy, material flow, etc
  - Identify potential component improvements
  - Fine-tune solvent formulations

Thank You

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